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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)


(51) International Patent Classification 3 : C12P 5/02; C02F 11/04
A01C 3/02

A1

(11) International Publication Number: WO 84/ 00038

(43) International Publication Date: 5 January 1984 (05.01.84)

(21) International Application Number: PCT/DK83/00058

(22) International Filing Date: 3 June 1983 (03.06.83)

(31) Priority Application Number: 2713/82

(32) Priority Date: 16 June 1982 (16.06.82)

(33) Priority Country: DK



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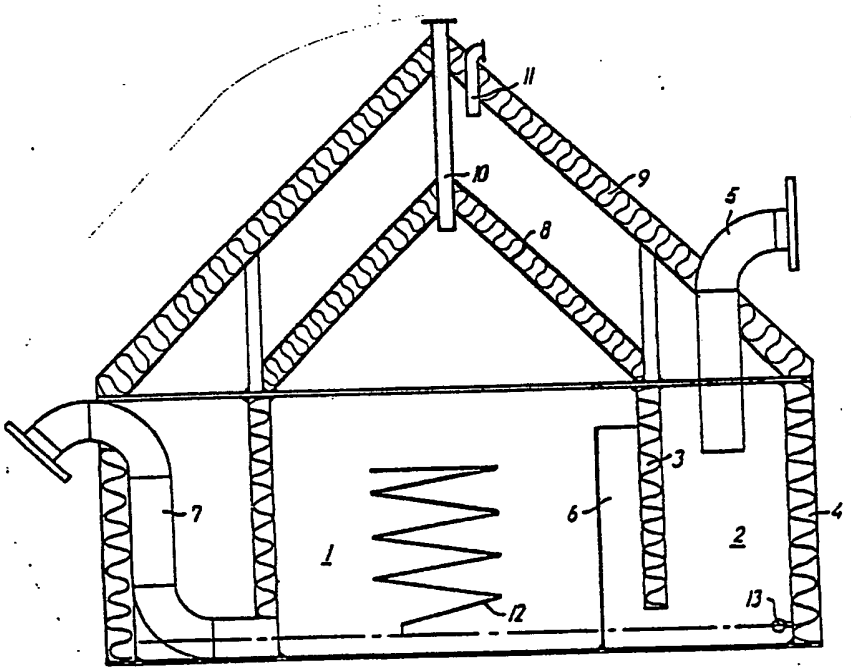
(81) Designated States: AT (European patent), BE (European patent), CH (European patent), DE (European patent), FI, FR (European patent), GB (European patent), LU (European patent), NL (European patent), NO, SE (European patent), US.

Published
*With international search report.*
*With amended claims and statement.*
*In English translation (filed in Danish).*


(54) Title: PROCESS AND PLANT FOR PRODUCING BIOGAS


(57) Abstract

In the production of biogas, an improvement in respect of energy economy with lower heat consumption and shorter processing time and at the same time an odourless degassed animal manure of high fertilizing value and free of pathogenic organisms is obtained by digestion of manure in a continuous process in which the supplied manure is, in two separate, successive digestion tanks, first subjected to a mesophilic digestion at a temperature of about 35° C and afterwards to a thermophilic digestion at a temperature of about 55° C. The tanks can be designed as an inner digestion tank (1) for the thermophilic digestion and a surrounding outer digestion tank (2) for the mesophilic digestion, separated by a common heat-insulating wall (3) in connection with which a transfer duct (6) for transferring mesophilically digested manure from the bottom of the outer tank (2) to the top of the inner tank (1) constitutes the only connection between the two tanks.

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Process and plant for producing biogas.

This invention relates to a process for producing biogas by digestion of animal manure under production of methane by a continuous process, in which fresh animal manure is supplied to a digestion tank concurrently with the removal of degassed manure from the tank.

In known biogas plants, the treatment of the supplied manure takes place in a single digestion tank either by a so-called mesophilic process where the digestion and the accompanying production of methane take place at a comparatively low temp-rature of about 35°C, or by a thermophilic process in which the digestion with a more complete degassing of the manure takes place at a temperature of about 55°C. The mesophilic process requires a comparatively long treatment time if a reasonable amount of gas is to be evolved, and a complete degassing of the manure is difficult to achieve; at the same time, mesophilic process does not make it possible to remove completely pathogenic organisms from the treated manure which after having passed the biogas plant is to be used for fertilizing purposes.

By the thermophilic process, one achieves a more complete degassing of the manure, but in order to maintain the comparatively high digestion temperature, it is necessary, especially at low outdoor temperatures, to supply a substantial amount of energy to heat the digestor, which reduces the efficiency in respect of energy economy to such an extent that up till now the thermophilic process has not been extensively used, in spite of the fact that it offers substantial environmental advantages owing to the fact that it results in a degassed manure of a very high fertilizing value, practically odourless and also free of pathogenic organisms, such as intestinal worms and various pathogenic bacteria, which were contained in the fresh manure.

With a view to overcoming the energetic and environmental drawbacks of existing biogas plants, the process according to the invention is characterized in

that the supplied animal manure is, in two separate, successive digestion tanks, subjected first to a mesophilic digestion at a temperature of about 35°C and afterwards to a thermophilic digestion at a temperature of about 55°C.

By subjecting successively the animal manure first to a mesophilic digestion and then to a thermophilic digestion, one obtains in the first place an environmentally valuable process making the degassed manure intended for fertilizing purposes both odourless and free of pathogenic organisms, so that the process according to the invention is particularly suitable for use in collective plants treating manure from a plurality of farms, as it ensure that the degassed manure returned to each farm for fertilizing purposes is not infected with pathogenic organisms of foreign origin.

Moreover, as a result of the first mesophilic digestion process a more homogeneous manure material is supplied as starting material for the subsequent thermophilic process, in which starting material plant residue and organic refuse from the vegetable production, such as litter straw, have been decomposed to a substantial extent as compared to fresh manure. Consequently, the processing time for the complete degassing of manure by the thermophilic process is substantially shorter than in the case of a thermophilic process carried out from fresh manure. In the process according to the invention the duration of the thermophilic digestion will typically be of about 6-8 days, while a thermophilic process on basis of fresh manure will typically require a processing time of 3 to 4 weeks.

For carrying out the process, a plant according to the invention is characterized in that it comprises an inner digestion tank provided with heating members for the thermophilic digestion of manure at a temperature of about 55°C, and a surrounding outer digestion tank for the mesophilic digestion of manure at a temperature of about 35°C, which tanks are separated by a common heat-

insulating wall and communicate with each other only through a duct provided adjacent to the said wall for transferring mesophilically digested manure from the bottom of the outer tank to the upper part of the inner tank, an inlet duct for fresh manure opening into the upper part of the outer tank and an outlet duct for degassed manure passing from the bottom of the inner tank througt the outer tank, while outlet ducts for the methane gas are respectively connected with each of two separate chambers which are placed above the tanks and are open towards their respective tank.

This embodiment of the biogas plant with coaxial cylindrical tanks results in a further improvement of the energetic efficiency since the surrounding of the thermophilic digestion tank by the mesophilic digestion tank will further reduce the total heat requirement for digestion and degassing of a given amount of manure per time unit.

The invention will in the following be explained in more detail with reference to the schematic drawing showing a section of an embodiment of a biogas plant according to the invention.

In the embodiment shown, the biogas plant comprises an inner thermophilic digestion tank 1 surrounded by an outer mesophilic digestion tank 2, the two tanks being separated by a common heat-insulating wall 3. The outer tank 2 has also a heat-insulating outer wall 4.

An inlet duct 5 for fresh animal manure opens into the upper part of the outer tank 2, while in connection with the common wall 3, provision is made of a connection duct 6 for transferring the mesophilically digested manure from the bottom of the outer tank 2 to the top of the inner tank 1. From the bottom of the inner tank 1, an outlet duct 7 for degassed manure passes through the outer tank 2 and the upper part of the outer wall 4.

At the top, each of the tanks 1 and 2 is

closed by its respective heat-insulating roof, 8 and 9 respectively, so that there is no air connection between the two tanks but only connection through the transfer duct 6. Outlet ducts 10 and 11 for methane gas from the inner tank 1 and the outer tank 2, respectively, are passed through the roofs 8 and 9, respectively.

The biogas plant according to the invention is of the so-called displacement type where the digestion process is continuous, since once the process has been started, the supply of fresh manure through the inlet duct 5 takes place concurrently with the removal of degassed manure through the outlet duct 7 and its conveying to a storage vessel (not shown). The levels of manure in the inner tank 1 and the outer tank 2 will be determined by the position of the lead-in of the outlet duct 7 through the outer wall 4 and of the opening of the transfer duct 6 into the inner tank 1.

For heating the inner tank 1 in order to maintain the temperature of about 55°C necessary to the thermophilic digestion process, provision is made of a heating coil 12, while a heating pipe 13 is provided for the occasional heating of the outer tank 2 in cold periods, in order to maintain the temperature of about 35°C for the mesophilic digestion process.

The tanks 1 and 2 may, moreover, be provided with devices for instance in the form of circulating pumps for stirring the manure and thus preventing the formation of a so-called floating (supernatant) layer at the top of the tanks. Such stirring devices can also in a conventional manner be further designed for comminuting manure, in particular in the outer tank 2.

# PATENT CLAIMS

1. A process for producing biogas by digestion of animal manure under production of methane by a continuous process, in which fresh animal manure is supplied to a digestion tank concurrently with the removal of degassed manure from the tank, characterized in that the supplied animal manure is, in two separate, successive digestion tanks (1, 2), subjected first to a mesophilic digestion at a temperature of about 35°C and afterwards to a thermophilic digestion at a temperature of about 55°C.

2. A process as claimed in claim 1, characterized in that the mesophilic digestion is continued until a substantially homogeneous manure material to be supplied to the digestion tank (1) for the thermophilic digestion is obtained, and that the duration of the thermophilic digestion is substantially shorter than the duration of the mesophilic digestion.

3. A process as claimed in claim 1 or 2, characterized in that the duration of the mesophilic digestion is of about two weeks, while the duration of the thermophilic digestion is of 6 to 8 days.

4. A plant for carrying out the process according to claim 1 or 2, characterized in that it comprises an inner digestion tank (1) provided with heating members (12) for the thermophilic digestion of manure at a temperature of about 55 C,and a surrounding outer digestion tank (2) for the mesophilic digestion of manure at a temperature of about 35°C, which tanks are separated by a common heat-insulating wall (3) and communicate with each other only through a duct (6) provided adjacent to the said wall for transferring mesophilically digested manure from the bottom of the outer tank (2) to the top of the inner tank (1), an inlet duct (5) for fresh manure opening into the top of the outer tank (2) and an outlet duct (7) for degassed manure passing from the bottom of the inner tank (1) through the outer tank (2), while common outlet ducts (10, 11) for the methane gas

are respectively connected with each of two separate chambers placed above the tanks (1, 2) and open towards their respective tank.

5. A plant as claimed in claim 4, characterized in that the common wall (3) between the inner and the outer tank (1, 2) and an outer wall (4) for the outer tank (2) are formed of coaxial, substantially cylindrical walls.

AMENDED CLAIMS
(received by the International Bureau on 19 October 1983 (19.10.83))

AMENDED P A T E N T C L A I M S (PCT Article 19)

1. A plant for producing biogas by digestion of animal manure under production of methane by a continuous process, in which fresh animal manure is supplied to a digestion tank concurrently with the removal of degassed manure from the tank, characterized in that it comprises an inner digestion tank (1) provided with heating members (12) for the thermophilic digestion of manure at a temperature of about 55°C, and a surrounding outer digestion tank (2) for the mesophilic digestion of manure at a temperature of about 35°C, which tanks are separated by a common heat-insulating wall (3) and communicate with each other only through a duct (6) provided adjacent to the said wall for transferring mesophilically digested manure from the bottom of the outer tank (2) to the top of the inner tank (1), an inlet duct (5) for fresh manure opening into the top of the outer tank (2) and an outlet duct (7) for degassed manure passing from the bottom of the inner tank (1) through the outer tank (2), while outlet ducts (10, 11) for the methane gas are respectively connected with each of two separate chambers placed above the tanks (1, 2) and open towards their respective tank.

2. A plant as claimed in claim 1, characterized in that the common wall (3) between the inner and the outer tank (1, 2) and an outer wall (4) for the outer tank (2) are formed of coaxial, substantially cylindrical walls.

## STATEMENT UNDER ARTICLE 19

In view of the prior art described in AU-B-485.782, DE-C- 630.242 and abstract of JP 56-108.591, cited in the international search report, the claims have been limited to a plant for producing biogas by cancelling original claims 1 to 3 and maintaining original claims 4 and 5 as amended claims 1 and 2.

The introductory part of new claim 1 has been amended in accordance with the introductory part of original claim 1.

In claim 1, line 24 the word "common" has been deleted for not being in conformity with the specification and drawing.

In compliance with PCT Article 19.2 the amendment does not go beyond the disclosure in the international application as filed.

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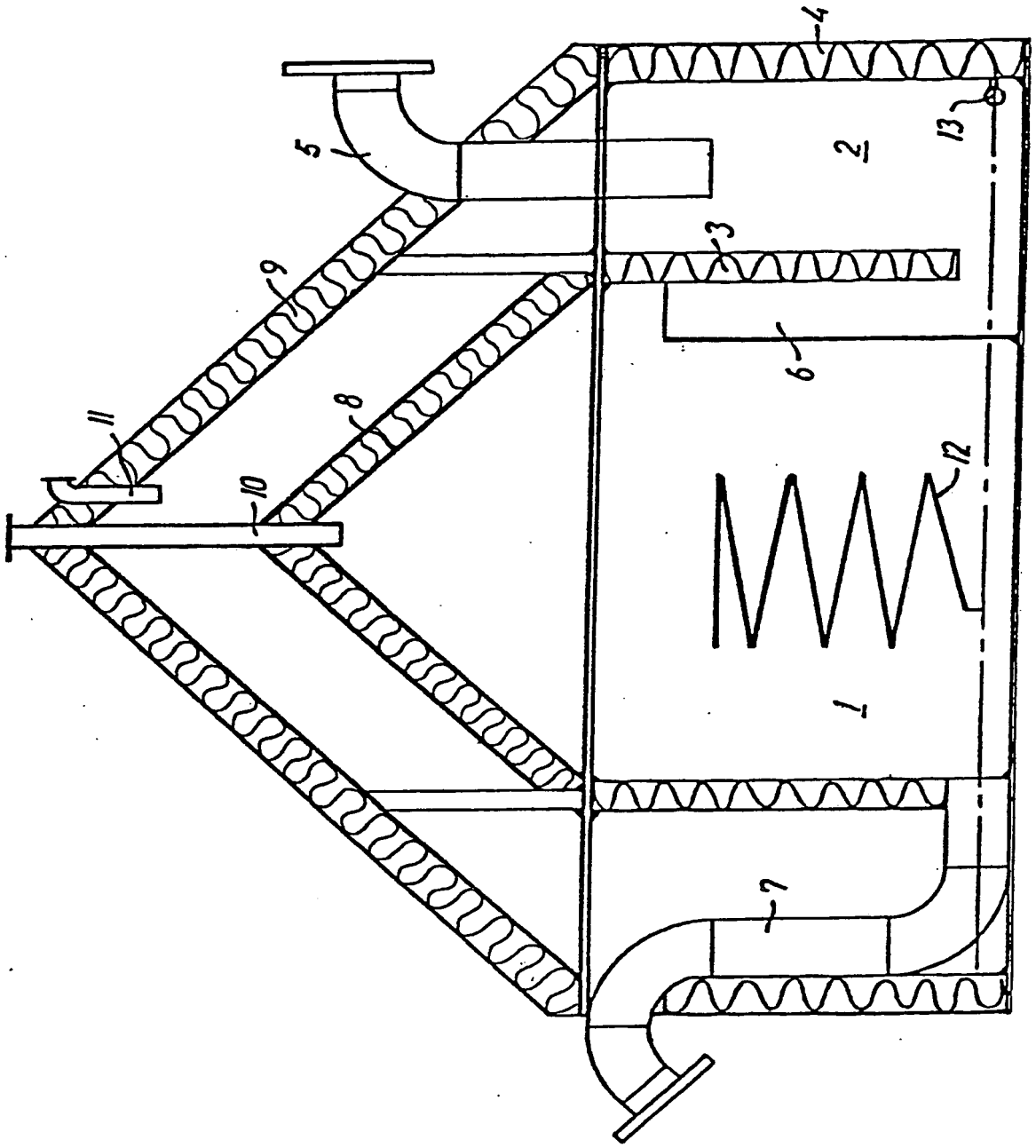

# INTERNATIONAL SEARCH REPORT

International Application No PCT/DK83/00058

## I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [5]

According to International Patent Classification (IPC) or to both National Classification and IPC 3

C 12 P 5/02, C 02 F 11/04, A 01 C 3/02

## II. FIELDS SEARCHED

Minimum Documentation Searched [6]

| Classification System | Classification Symbols |
|---|---|
| IPC 3 | A 01 C 3/00,02, C 02 F 3/28, 11/04, C 05 F 5/02, C 12 M 1/00, C 12 P 5/02 |
| US Cl | 71:8-10; 195:3; 210:2,16,601-613; 435:166,167,287, 302 |

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [6]

SE, NO, DK, FI classes as above

## III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

| Category [15] | Citation of Document, [16] with indication, where appropriate, of the relevant passages [17] | Relevant to Claim No. [18] |
|---|---|---|
| X | AU, B, 485 782 (STANLEY BEAUMONT) 4 August 1977 & AU, 59599/73 | 1, 2 |
| X | DE, C, 630 242 (FRANZ FRIES) 30 April 1936 | 4, 5 |
| A | DE, A1, 3 042 883 (HANS SCHNEIDER) 9 June 1982 | 1 |
| A | Patent Abstracts of Japan, abstract of JP 56-108 591, published 1981-08-28 | 1 |
| A | SE, A, 8002342-7 (OY YLEINEN INSINÖÖRI-TOIMISTO) 27 September 1981 | 1 |
| A | GB, A, 462 941 (DORR CO) 18 March 1937 | 1 |

* Special categories of cited documents: [19]

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## IV. CERTIFICATION

| Date of the Actual Completion of the International Search [2] | Date of Mailing of this International Search Report [2] |
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| 1983-08-22 | 1983 -08- 26 |
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